632.111:633.11

GROWTH CHARACTERISTICS OF MUSTARD CROP IN RESPONSE TO THERMAL ENVIRONMENT UNDER ARID CONDITION

1. To study the influence of thermal environment on biomass production and grain yield of mustard (*Brassica juncea* L. *Czern* and *Coss* C.V. Pusa bold) grown in three gravimetric lysimeters during rabi seasons of 1986-87 and 1987-88 field experiments were conducted. Ambient temperature relationship with phenology, and biomass accumulation were studied with crop maintained at different irrigation rates in sandy loam soils of the region. Heat use efficiency and crop growth rate of mustard crop were presented and discussed. The study reveals that the reduction in heat units by 24 per cent during vegetative and elongation phases of mustard decreased grain yield by 8 to 10 per cent.

2. Influence of temperature on phenology and biomass production in different crop plants can be studied under field conditions through the accumulated heat unit system. Such studies for wheat were reported by Nuttonson (1955), Chakravarty and Sastry (1983) and Sastry *et al.* (1985). Based on accumulated heat units, heat use efficiency is calculated to study the relative response of different irrigation treatments on biomass production and yield of mustard crop.

3. *Material and method* — Field experiments were conducted at Central Arid Zone Research Institute Farm, Jodhpur (26° 18′ N, 73° 01′ E) on mustard (*Brassica juncea* L. *Czern* and *Coss* C. V. Pusa bold) during two rabi seasons 1986-87 and 1987-88 (Nov to Feb). The crop was grown under control, 50% potential evapotranspiration (PET) and 100% potential evapotranspiration (PET) irrigated conditions. The daily evapotranspiration (ET) rates under these three levels of irrigations were measured using gravimetric lysimeters installed in the mustard field. Field plots of 2.0 m × 2.5 m were made around these lysimeters maintaining the above irrigation levels surrounded by plots of controlled crop. In both the years, mustard was sown during second week of November after a pre-sowing irrigation of 50 mm. The controlled crop received three more irrigations (50 mm each) till it reached flowering and pod formation stage. The 100% PET crop was irrigated daily from 20 days onward with an amount equal to the ET loss of the previous day. The 50% PET crop was irrigated on every 4th day with an amount equal to half of the cumulative PET recorded from the lysimeter maintained at potential irrigation rate (100% PET) during the previous 4 days. The crop spacing was adjusted to 30 cm × 10 cm. The soils in the area were sandy loam. There was 6 mm of rainfall during 1986-87 rabi season whereas 11 mm for the corresponding period in 1987-88.

The dates of occurrence of different phenological events were noted for all the replicates reached the respective stage. Accummulated growing degree days (heat units) were computed with 5°C as a threshold temperature following Nuttonson (1955) using daily maximum and minimum temperatures recorded in the meteorological observatory located adjacent to the experimental site. Plant biomass (above ground) samples were collected randomly from replications at weekly intervals and oven dried at 80°C to constant weight. Heat use efficiency (HUE), the biomass (gm^{-2}) production per unit degree day (°C), was computed following Sastry *et al.* (1985) for studying biomass accumulation pattern in relation to ambient temperature between different growth stages. Crop growth rate (CGR) the biomass accumulation per day ($gm^{-2}day^{-1}$) were also derived between two different phenological stages of crop growth.

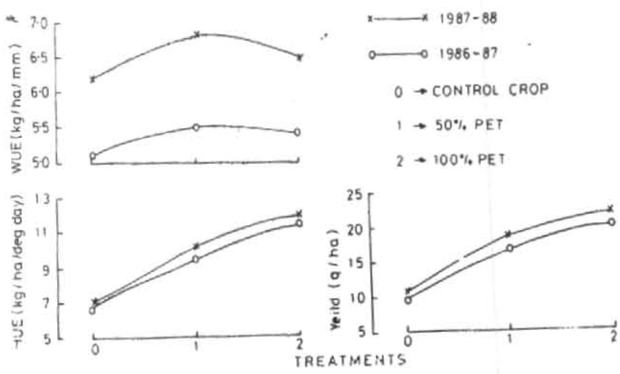

Fig. 1. Yield, HUE and WUE of mustard under different moisture regimes

4. *Results and discussion* — The mustard crop maintained at 100 per cent and 50 per cent PET rates during the two growing seasons recorded consistently higher dry matter production at each stage of growth as compared with control crop (Tables 1). The dry matter production rates were higher by 48-52% under 50% PET irrigation and by 67-68% under 100% PET irrigation. Similarly CGR were more by 46-51% under 50% PET irrigation and by 62% under 100% PET irrigation. This clearly shows that irrigation beyond 50% PET had no linear type relationship with the total biomass, heat use efficiency and crop growth rate of mustard crop grown during two rabi seasons of 1986-87 and 1987-88.

The heat use efficiency was found less during vegetative phase (from 30th to 60th day after sowing) by 2 to 3% and crop growth rate by 22 to 23% during 1986-87 in compared to 1987-88. This low HUE and CGR is due to low air temperatures prevailed over the region for a continuous period of 22 days during vegetative growth and elongation phases of 1986-87. During crop vegetative and elongation phases low ambient temperature by 1 to 8°C for a continuous period of 22 days in 1986-87 caused less accumulation of heat units by 24% as compared to the corresponding period in 1987-88. The lowest temperature recorded during growing season of 1986-87 was —0.2°C and 1987-88 was 10.3°C in the meteorological observatory adjacent to the experimental area. Although equal irrigations were given during both years but crop could not utilize water efficiently during 1986-87 only because of the continuous persistence of cold wave (low ambient temperature) over the region. Finally this low air temperature caused significant reduction in total biomass as well as grain yield during 1986-87.

The consumptive use values of mustard crop were 189, 289 and 364 mm during 1986-87 and 167, 260 and 327 mm during 1987-88 under control, 50% PET and 100% PET rates respectively. The accumulative heat unit from sowing to maturity date of mustard

TABLE 1

Heat use efficiency (g/m²/°day) and crop growth rate (g/m² day) of mustard crop (above ground biomass) at different growth stages during 1986-87 and 1987-88 rabi season at Jodhpur

Days after sowing	Net increase in biomass (g/m²)	Growing degree days (Heat units)	HUE (g/m² deg. day)	CGR (g/m² day)
		Control (1986-87)		
30	26	511	0.05	0.9
60	280	343	0.84	9.6
90	209	432	0.48	7.0
111	155	349	0.44	7.4
Total/Mean	679	1635	0.42	6.1
		50% PET		
30	30	511	0.06	1.0
60	464	343	1.35	15.5
90	308	432	0.71	10.3
113	202	391	0.82	8.8
Total/Mean	1004	1677	0.60	8.9
		100 % PET		
30	36	511	0.07	1.2
60	340	343	1.57	18.0
90	313	432	0.72	10.4
115	252	433	0.58	10.1
Total/Mean	1141	1719	0.66	9.9
		Control (1987-88)		
30	26	545	0.05	0.9
61	384	449	0.86	12.4
90	202	429	0.47	7.0
107	124	300	0.41	7.3
Total/Mean	736	1722	0.43	0.9
		50% PET		
30	32	545	0.06	1.1
61	621	449	1.36	20.0
90	303	429	0.71	10.4
108	162	318	0.51	9.0
Total/mean	1118	1741	0.64	10.4
		100% PET		
30	37	545	0.07	1.2
61	724	449	1.61	23.4
90	315	429	0.73	10.9
110	160	351	0.46	8.0
Total/Mean	1236	1774	0.70	11.2

crop at Jodhpur were found to vary from 1635 to 1774 depending on the moisture availability to the crop. The lower heat unit corresponds to control crop and higher value corresponds to the crop maintained at 100% PET rates. The heat use efficiency (HUE) and water use efficiency (WUE) of mustard crop with respect to grain yield is presented in Fig. 1. The study revealed that 3 to 5% decrease in total accumulated heat units caused 8 to 10% decrease in grain yield during 1986-87 as compared to the yield in 1987-88. HUE of the mustard crop maintained at 50% PET rates is higher by 61 to 70% and at 100% PET is higher by 95 to 100% in compared to grain yield of control crop. Hence it indicates that crop maintained at higher rate of PET utilizes better thermal regime than the control crop. But this study also reveals that HUE with respect to biomass and grain yield increases linearly up to 50 per cent PET and afterward its trend is non-linear as in the case of water use efficiency (WUE) reported by Ramakrishna *et al.* (1990).

5. *Conclusion* — The mustard crop maintained at 50% potential evapotranspiration rates utilized available thermal and moisture regime efficiently for its growth and production of grain yield. The low air temperatures by 1° to 8° C during vegetative phase causes 2 to 7% reduction in HUE with respect to the yield of mustard crop. Also the heat use efficiency and crop growth rate facilitate relative assessment of crop response to prevailing thermal environment at different growth stages and hence these parameters can be considered as a measure of crop growth character in response to ambient temperature.

6. The authors are grateful to Dr. J. Venkateswarlu, Director, Central Arid Zone Research Institute, Jodhpur for his keen interest and encouragement shown in the present study.

References

Chakravarty, N.V.K. and Sastry, P.S.N., 1983, Biomass production in wheat in relation to evaporative demand and ambient temperature', *Mausam,* **34,** 3, pp. 227-230.

Nuttonson, M.Y., 1955, 'Wheat climate relationships and use of phenology in ascertaining the thermal and photothermal requirements of Wheat', American Institute of Crop Ecology, Washington, D.C., 338 pp.

Ramakrishna, Y.S., Rao, A.S., Singh, R.S. and Joshi, N.L., 1990, 'Effect of irrigation on evapotranspiration, water and energy use efficiency of mustard crop', *Annals of Arid Zone,* **29,** 4, pp. 259-264.

Sastry, P.S.N., Chakravarty, N.V.K. and Rajput, R.P., 1985, 'Suggested index for characterisation of crop response to thermal environment', *Int. J. Ecol. Environ. Sci.,* **11,** pp. 25-30.

R. S. SINGH
A. S. RAO
Y. S. RAMAKRISHNA

Central Arid Zone Research Institute,
Jodhpur
17 August 1990